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THE SPOT-DIAL,

Very useful to shew the *Hour within the House.*

Together with Directions how to find a true *Meridian*, the *Azymuth* and *Declination*; and how to draw a *Dial* upon a *Staff*, upon the *Cieling*, upon any *Pillar* or *Globe*.

Never before Published.

By *GILBERT CLERKE.*

LONDON,

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BIBLIOTHECA BODLEIANA

Courteous Reader,

I *Did not think to have written any more of Dialling, having delivered my Mind ſufficiently at the End of my* Oughtredus Explicatus; *but being deſired by a Neighbour Gentleman to make a fuller Deſcription of the* Spot-Dial, *which I mention there, p.* 21. *I have now undertaken it, according to that Gentleman's Deſire, having had much Experience (ſince that Writing was extant) both of the beſt ways of drawing the Dial, and of the beſt Materials, and ſo much as I believe, that little will be added by him, that comes after, to what I ſhall here ſay.*

The Uſe of this Dial is to ſee the Hour by the Rays of the Sun paſſing through a Hole, and terminated in a Glaſs ſet in a Frame within the Houſe againſt the Window, the Ground of it is the ſame with that of the Sun's Light paſſing through a Hole in the Window, and intercepted by a String, and of the Cieling-Dial, *where the Reflecting-Glaſs is ſuppoſed to be a Point in the Style.*

If you aſk me what is the Uſe or Convenience in this, more than in other Dials, I anſwer,

1. *It is cheaper.*

2. *I can see the Hour without going out of Doors.*

3. *I can see by a fleeting Sun.*

4. *It is easily removed to any Window in the same House, or any other of the same, or near the same Declination.*

5. *If an Errour of two or three Degrees be committed in taking the Declination, you may make the Dial true to the supposed Declination, and all the Inconvenience will be, that it will not so exactly range with your Window.*

6. *Which is the chiefest of all, you may see by a very faint Sun, when you cannot see the Hour upon a Wall-Dial. I have always much esteemed the Cieling-Dial, but I find that it will not discover the Hour so easily as this, and not at all when the Sun is low in the Morning or in the Evening: The common Painted anneal'd Dials are not to be made by every man, are too dear for ordinary Use, besides that for low Windows and toward the Street, their* Gnomon *are subject to too much Offence.*

Farewel.

To find a True Meridian, *the* Azymuth *and* Declination.

IN the first place, It is very necessary to have a True *Meridian*, which may be obtained many ways, but the best I know for Practice is this;

Get a plain thick Board of a Foot-square, or more, then upon one of the Edges or Corners, as near as may be, fasten a strong Iron pin, about ten or eleven Inches long, and make it so fast, that it will not shake or yield in the least: it matters not whether it be perpendicular or not.

Set this Board horizontally in your Garden, with Earth or Sand upon the Ground, or as you may, about Nine a Clock (and to chuse when the Sun is near the *Solstice*, suppose, about the 10*th* of *June*), see where the Head of this Iron-pin (which must be sharp at Top) giveth its Shadow upon the Board, mark that Place: Then take a Wooden Ruler, sharp also at one End, and lay it so, upon the sharp End of the Iron-pin, that the sharp End of the Ruler, may touch the Mark, then carrying it steady, make a Segment of a Circle towards the North.

Come again about three a Clock in the Afternoon, and mark where the Shadow of the top of the Iron-pin is in that Segment again.

Draw a Line from those two Marks, which will be East and West, and the perpendicular to that Line, will be a *Meridian*, and if you halve that Line, the perpendicular will go through the Center of the whole

whole Circle; for that Segment is part of the *Base* of a *Cone*, whose *Vertex* is the top of the Iron-Pin.

But now because the Sun may be under a Cloud when you come at Three a Clock, you may make three or four more Segments, and use them as you used this.

This Method would be very exact, if the Sun moved as the fixed Stars do; but because the Sun hath a proper Motion as a Planet, there will be some inconsiderable Errour, which yet may be corrected: for seeing the Sun in one Minute of an Hour, moveth as much by his daily Motion, as he loseth in six Hours by his proper Motion; you shall add as much in the way, which the Shadow goes to the last Mark, as that Shadow moved in one Minute, which you may measure by your Pulse or a *Pendulum*, so the last Point will not be taken just in the Segment, but a little without it.

I do think you will hardly by the altitude of the Sun and *Azymuth*, (though your Instruments be good) calculate a *Meridian*, so near the truth. When you have a true *Meridian* in your Garden, you may transplant it by Observation, to any other place not very far off, as to the *Transum* of your Window by the Shadow of the *Stanchel*, &c.

When you have a True *Meridian*, you may easily find the Sun's *Azymuth*, or Distance from the South; for hold but up a Plumb-line, and the Angle which the Shadow maketh with the *Meridian*, is the *Azymuth*; or you may lay the Edge of your Quadrant to the *Meridian*, and the Shadow of the Plumb-line passing through the Center, will give you the *Azymuth* in the Line, and better than if you calculated it by the altitude of the Sun as before.

Lastly,

Laſtly, If you have the *Azymuth*, it is not hard to find the *Declination* of any Wall; for apply your *Quadrant* horizontally to the Wall, by one ſide of it, and mark in the Limb the Angle which is made, by the Shadow of a Plumb-line (through the Center) with the other ſide of the Quadrant, which is perpendicular to the Wall, at the ſame time you take the Angle for the *Azymuth*.

Theſe two Angles being known, the *Declination* will be alſo known.

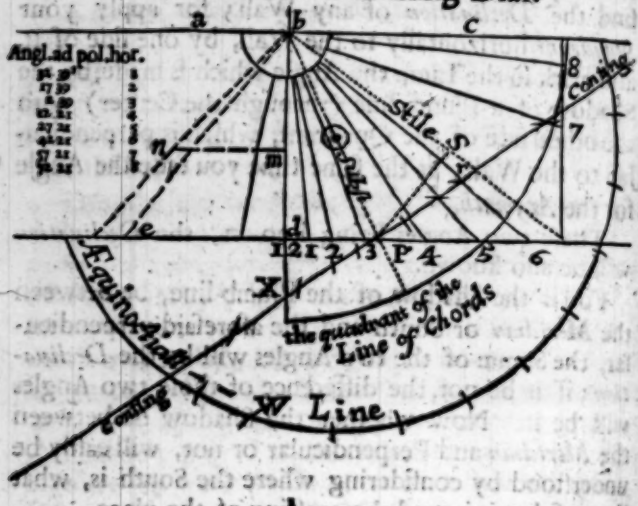
For if the Shadow of the Plumb-line, be between the *Meridian* or South and the aforeſaid perpendicular, the Summ of the two Angles will be the *Declination*; if it be not, the difference of thoſe two Angles will be it. Now whether the Shadow be between the *Meridian* and Perpendicular or not, will eaſily be underſtood by conſidering where the South is, what time of day it is, and the coaſting of the place.

But ſeeing the *Declination* is the Angle contained between the Perpendicular from the Wall and the *Meridian*, it may be beſt to wait in fair weather, till you find the Sun in the *Meridian*; and then the Angle upon the Limb of the Quadrant, will it ſelf be the *Declination*.

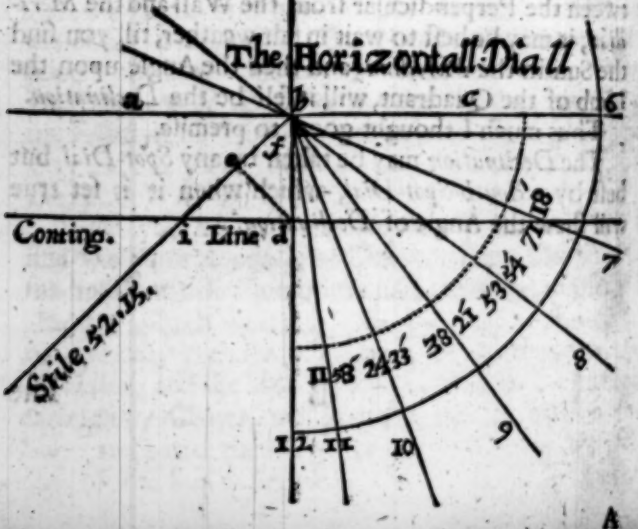
Thus much I thought good to premiſe.

The *Declination* may be taken by any *Spot-Dial*, but beſt by a *South-Spot-Dial*, which when it is ſet true will ſhew the Angle of *Declination*.

The Vertical Declining-Dial.



The Horizontall Dial



A DESCRIPTION OF THE Spot-Dial.

THE *Spot-Dial* is of two ſorts; in the one the Lines go to a black Spot, in the other a bright Spot goes to the Lines; which latter being explained, the former cannot be unknown.

The Materials are Tin, a Frame and Glaſs.

I buy a ſheet of Tin of the Iron-Monger for 5*d.* which will ſerve for many Dials.

And for my ordinary Friends, the Frame of wood will not coſt much more. I get the Carpenter to ſhoot two Rulers of *Firr-Deal*, one having five Surfaces, much like a Ledge of a Book-Desk, out of this I cut one longer piece, about ſix or ſeven Inches long, as occaſion ſerves for a Top-piece, the loweſt and broadeſt *Superficies* whereof, to be about one Inch and quarter.

I cut alſo two ſhorter pieces for Jaumes or Side-pieces, each about 2 Inches and ½ long, and making Rappits in them with a Saw, (or otherwiſe) for the ends of the Glaſs to go into, and ſo as the Glaſs may be one Inch (or thereabouts) diſtant from the out-

wardmoſt edge, or Tin. I nail the Top piece on the Jaumes with long Tacks without heads, which will be ſtrong enough, when the Plate of Tin is nailed with little Tacks upon the back-ſide of the Frame.

Then with other long Tacks, I nail the bottom-piece to the bottom of the Jaumes, and I bore the holes for theſe Tacks with an Awl ſo deep, as that it may be taken off at any time with my knife, without much difficulty; I cut this bottom-piece out of the other Ruler, which therefore is flat and ſomewhat wider, that the Frame may inſiſt the better upon it as a *Baſis*.

But for my extraordinary Friends, I get the Joyner to make moulded Frames with miter-joynts, like the Frame of an *Ebony* Looking-Glaſs; and ſuch curious Frames as are made for Pictures, gilt, of *Ebony* or *Ivory*, with little Globes and Pyramids at the top, might be made, as would be ornamental, and would become the beſt Lady's Cloſet in the Land. The other Material is glaſs; I did at firſt uſe paper, which will repreſent the Spot very well, but was apt to crumple and crook the Lines, and in ſome windows to grow odiouſly foul in a little time; then I procured a plain thick Horn, which would ſhew the Spot in the clear parts, but it had too many black and dark patches in it; after many trials of gumming Paper and Sarſenet upon Glaſſes, which for one fault or other I liked not, I procured anealed Glaſs from *London*, which did very well; I did alſo with *Calice*-Sand grind Cryſtal Glaſs, and other common Glaſſes, upon an iron plate, or the Cryſtal Glaſſes one upon another, which in repreſenting the Spot, were not much inferiour to anneal'd Glaſs; but which I liked better, becauſe I could procure them with leſs trouble, and they have this convenience, that

if

I make any fault, I can quickly grind it out, and begin again; I would for Curiosity's sake have tryed Ivory plates, or thin plates of such bone as they make Bone Combs of, but I fail'd in procuring them, and was not eager, being so well satisfied with the former Glasses: besides I doubted whether that matter would so well endure the violence of the Summer Sun.

I had very fine lanthorn Horns sent me, but they would not serve, first, because they were buckled, and then because they were so thin as to be transparent; for it is essential to my purpose, that the matter should be lucid as paper, but not so transparent that any thing may be seen through it: for the light will penetrate such Glasses, and not terminate in them, for which reason I found my self deceived, when I thought that red, blue, or other coloured Glasses, would effect what I desired; except they were also ground: at last, I happened upon Materials which did throughly please me, and were cheap enough, for that was a main thing, which I did design in these Dials. But in grinding glasses, you must have a great care not to grind the other side; for in a little time you may so smutch the glass by heedless mistake of the side, as to make it useless.

You can hardly break Crystal Glasses, but common Glass will ever and anon break, by some greater Grit in the Sand, or leaning too hard, or by reason of some crookedness in the Glass: therefore chuse as plain and even Glasses, as you can; yet the broken pieces may often serve for North-Dials.

Of

Of taking the Declination.

For the making of the Dial, first, find out the *Declination* of the Glass-window, against which you would set your Dial; which is easily done by a true *Meridian*; for having with a Plumb-line Pen and Ink, drawn a black-line upon the Quarry perpendicular to the plane of the *Horizon*; when the Sun is in the *Meridian*, apply a little quadrant Plate or Card horizontally to the Quarry, and mark the Angles, which the Shadow of the black-line maketh with that edge of the Card, which is next the Glass; for the Complement of that Angle taken off by a line of Chords, or otherwise, is the *Declination*.

Of making the Dial first upon Paper.

After you have the *Declination*, make a Dial upon Paper to that *Declination*, with Stile and Substile drawn upon the Paper, as if you were to make it for the Wall without doors, or outside of the Window.

Of the Glass first in the Frame.

Next put your Glass already ground, into the Frame, and take the neerest distance between your Glass and the Tin, or that side where the Tin is to be nailed; for this end make a square of Paper, and applying one side to the Glass now in the Frame, make a point at the neerest distance, and clip off the rest of the Paper at that point; with that distance come to the Dial on the Paper, and lay the longest edge of this Square to the Substile, and carry it backward or forward upon the

the Substile, till the marked point just toucheth the Style; then holding it, draw a Line from the Substile to the Style, and mark that point upon the Paper where this Line cutteth the Substile, *viz.* at the corner of the Square, which I call the Substile-point, and draw a round ⊙. about it, that I may know it again.

Of the Glass first taken out of the Frame.

Then take your Glass out of the Frame, and apply it to the Dial upon the Paper, laying the annealed Surface of the Glass uppermost, so as the very edge of the Glass may touch or just cover the Substile-point, and the other edge at the end which must go into the Rappit, may lie parallel to the *Meridian* upon the Paper as near as you can guess (which is sufficient), then remove the Glass toward the right hand, or toward the left, till it lies upon those Hours which will serve your turn best.

But note that if the *Meridian* be not under your Glass as it now lies upon the Paper, you must instead of it use a parallel to the *Meridian*, drawn first upon the Original, *i. e.* the Paper, and cast it so as that the perpendicular upon the Glass to be made with a Plumbline correspondent to the parallel, may fall as near one of the Jaumes; which will not be hard to do.

For so, this correspondent perpendicular on the one side, may direct for even placing the Figures on that side, then (that I may digress a little) draw with your Pointer a like Line on the other side, and another at convenient distance from the bottom of the Glass, for the Figures, which if you write upon the rough side (as you will find needful to do) must be made inverted,

verted, that is, for the Nine you must write Eleven, if you write in *Roman Letters*, which you must heed carefully; and therefore your best way is to have a Copy before you of Figures drawn wrong, and then you will find them to be right when all is put together.

Note also, that if the *Declination* be Westward, the backside of the Dial will serve for the same *Declination* Eastward. *Et contrà.* And by Vertical Inversion they will both serve for the like *Declinations* from the North, and every one must be inverted or re-inverted for that sort of Dials in which the Lines go to the Spot. But to return.

When you see which Hours will serve your turn best before you draw the Lines upon it, mark upon the Glass also the Substile-point, and likewise the point where the Edge of the Glass cuts the *Meridian* or Parallel aforesaid.

Of the Glass in the Frame the second time.

Then put the Glass into the Frame again, and from that point made against the *Meridian* or Parallel, or if you cannot well see it, from another as near as you can guess perpendicularly under it, let fall a Perpendicular by a Plumb-line, or make Marks.

Of the Glass taken out of the Frame the second time.

Then taking your Glass out of the Frame, draw that perpendicular upon the rough side of the Glass, with a Poynter, such as the *Glaziers* use, or a Diamond-spark in a Pencil, such as are sold at *London*, to write upon Glass; or if you want these, with the sharp point of

of your Pen-knife or of a Nail upon annealed Glass, and after draw your Pen over it once, and again (if need be) with good black Ink, next apply this new *Meridian* upon your Glass, to the *Meridian* upon the *Paper-Dial*: and because you may have guessed, as I said, if the Substile-point in your Glass do not lie just over that in the *Paper-Dial*, blot it out, and make another that will.

Of drawing the Hour-lines.

Now as your Glass lies upon the Paper as is directed, if it be common thin glass, keeping it steady upon the paper by your own Hand, or some Friends help, draw the Hour-lines, transplanting them from the paper to the Glass, as afore, with a Diamond if it may be, *&c.* but if it be thick Crystal Glass, transplant them first upon Paper of almost the bigness of the Crystal, and laying this lesser paper upon the Crystal, make Marks by which to draw the Hour-lines upon the Crystal, as you should have done if it had been thinner Glass and upon the Dial-paper.

Of the Time.

Lastly, Nail your Tin on the backside of the Frame, covering the better half of it, and in that Tin make the Hole perpendicularly over against the Substile-point, which you will find by the Paper square, by which you may draw a perpendicular Line from the Substyle-point, and ink it upon the Top piece: *i. e.* upon the broadest *Superficies* or Bottom of that.

Make the Hole with an Awl, laying it upon some hard Board, lest the Awl run in too far, and make the

Hole too big, rather thruſt no harder, than will make a diſcernible Pimple on the outſide of the Tin, to be cut off with your Knife, you may more eaſily make the Hole bigger than leſs. I make the Hole ſo near the Top, becauſe all above that is uſeleſs, and the Perpendicularity is more certainly found, by the Square, and which if it be miſtaken cauſeth the greateſt Errour.

The greateſt hazard being in making the Hole right, when you know very near, where it is to be, you may make the Hole in the Tin firſt, and ſetting your Frame in the Window, if you be ſure of the *Declination* of it, mark by your *Meridian* where the Spot is made at 12. a Clock, and then with the help of a Plumb-line having drawn a true *Meridian* upon your Glaſs, proceed, by the directions given, to ſet on the reſt of the Lines. This way is not very practicable.

Note, laſtly, that your Glaſs muſt have a proportionable length and breadth; in breadth for the *Meridian* Altitude of the Sun in *Cancer*, for the Spot will go down very low in Summer, but it will never go down twice the Profundity or Depth, *viz.* the diſtance between the Glaſs and the Tin, or neareſt diſtance.

By the Breadth I mean the neareſt diſtance between the Top-piece and the Bottom-piece, but as near as I could meaſure according to this following Table, ſuppoſing the Sun's greateſt *Meridian altitude*, to be 62. Degrees. But remember that allowance muſt be made at Bottom, for writing the Figures.

Depth.

Depth.	Breadth.	Depth.
$\frac{1}{2}$ Inch	$\frac{11}{12}$	$\frac{1}{2}$ Inch — $2\frac{1}{3}$
$\frac{3}{4}$	$1\frac{1}{3}$	1 — $5\frac{1}{2}$
1	$1\frac{13}{16}$	$1\frac{1}{2}$ — $8\frac{1}{2}$
$1\frac{1}{2}$	$2\frac{11}{16}$	2 — $10\frac{1}{2}$
2	$3\frac{10}{16}$	
$2\frac{1}{2}$	$4\frac{1}{2}$	
3	$5\frac{1}{2}$	

For the Length of the Frame and Glaſs that muſt be, as the Jaume of the Window and *Stanchel* will give leave; but if it be not long enough, or as the Hole may fall out, the Spot may fall upon the oppoſite ſide of the Frame, and ſo an Hour or more may be loſt, but for the moſt part the Length will be about the Proportion of the ſecond Table, *viz.* One Inch in depth will have $5\frac{1}{2}$ in length. You need not make any Hole in the Window-glaſs, for except the Glaſs be very foul, the Light will come through well enough, if the Lead do not obſtruct it.

Now I need not ſay much of that Form, wherein the Lines go to the Spot, for it is but the ſame inverted, as if you ſhould turn this upſide down, and draw the Lines toward the Window or Street, upon a clear tranſparent Glaſs, and on the inſide toward the Houſe inſtead of Tin, you have annealed Glaſs, with one black Spot at the bottom, where the Hole is in the Tin, unto which Spot every Line will come ſucceſſively, according to the time of the day, and the Figures muſt be written upon the clear Glaſs at top; but I make the leaſt uſe of this, becauſe it is hard to make handſome and durable Letters or Figures upon ſmooth Glaſs (poſſibly a Glazier might do it with his Poynter)

 and

and there must be a great square Glass behind it (which is not usual or troublesome to have) or else the Lead will make a very unhandsome confusion: besides, it doth not altogether represent so well by a faint light, as the Sun Beams will gild the Glass through the Hole: otherwise it hath more of prettiness and conceit in it; for when the Sun doth not shine, a stranger would little think that was a Dial, seeing nothing but a little black Spot, and very likely not that neither.

To make a Staff-Dial.

DRAW a Line upon Paper, as long as will go twice about your Staff; upon that Line as a Diameter make a Semicircle; from the equal Divisions of that Semicircle, let Perpendiculars fall upon the Diameter, as they use to do in making a Line of Signs.

The first point in this Line of Signs shall be for the Sun in the first degree of *Capricorn*, and the first of the next thirty degrees for the Sun, in the first degree of *Aquarius*, *&c.* according to the order of the Signs. And it is sufficient if 30. degrees be divided but into three Parts; which in the first and last thirty can hardly be done, nor is there need.

This Line of Signs, must be set horizontally upon the top of the Staff, round about it as shall be shewed. But from the Solstitial and Æquinoctial Points (and from others, as the 10*th.* of ♉. or the 10*th.* of ♍. when there is need) Perpendiculars should be drawn

down

down the Staff; but for the more practicable Description of the Dial, representative Perpendiculars shall be drawn upon the Paper, which shall be as Tangents, whose *Radius* shall be the Style, which must insist perpendicularly upon the Staff, and Line of Signs.

The *Meridian* altitudes of the Sun in the Solstitial and Æquinoctial Points, must be computed and noted in the Tangents upon the Paper, and through the noted points let a Circle be described upon the Paper, as *Euclid* hath taught to draw one through any three Points, for the Hour of 12. and in like manner for the rest of the Hours; for which therefore you must calculate a Table of Altitudes, according to the Elevation of the Pole: *viz.* for every Hour Mr. *Wingate's Analogies*, as in these Examples; see also *Fale*, *p.* 50, where he giveth Tables for 50. and 52.

For 52*o Degr.* 25'.

Hours.	♋		♎		♈		10. ♉		10. ♊	
12	61	5	37	35	14	5				
11 1	58	54	36	6	12	58				
10 2	53	10	31	53	9	51				
9 3	45	22	25	33	4	34				
8 4	36	34	17	45			29	51		
7 5	27	17	9	5			20	48		
6	18	25	0	0			11	42		
5 7	9	52					2	53	8	0
8 4	2	13					0	0	0	0

As

At Stamford *the Pole is elevated* 52°. 40'. *or according to* Vincent Wing, 52° 41'

12		60	50	37	20	13	50				
11	1	58	40	35	51	12	43				
10	2	52	59	31	41	9	29				
9	3	45	15	25	24	4	22				
8	4	36	31	17	38			29	46		
7	5	27	20	9	2			20	40		
6		18	21	0	0			12	38		
5	7	9	50					20	50	8	0
8	4	2	10					0	0	0	0

Lastly, One half of the Line of Signs being like the other, let half of it be applyed to your Staff or Cylinder, and reflect the other half.

But note that either the Style or the Cylinder must be moveable, so that the Style the 10*th.* of *December* may be over the first point of the Line of Signs, and the 10*th.* of *January* over the first point of the next 30. and the 10*th.* of *March* over the last point, then you must go back, and so backward and forward through the whole Year.

If you do not understand what I have said, especially about the 10*th.* of ♉. (for you must have three points to describe every Hour-line: See *Fale's Quadrant*, *Chap.* 28.

The chiefest trouble about this Dial is in making either the *Radius*, or the Plate upon which the Lines are drawn, moveable.

But if the aforesaid perpendiculars, supposed to be drawn down the Staff, be indeed lightly expressed, and likewise a competent number of parallels to the Line

Line of Signs, all might be fixt, setting the *Radius* in the midst of that Line; for by the help of those parallels and turning the Staff a little, if needful, the Eye would presently discern where the Shadow would fall: Some when they are abroad, use a Ring-Dial, but that is not so ready at hand as this, and besides we cannot make it our selves, and therefore I forbear to describe the Making of it.

For the making a Cieling *or* Reflexive Dial.

FIRST, Determine the most convenient Point in the Window where to place the *Reflecting-Glass* as near the Cieling as you can conveniently, provided it be not so near as that the *Cornish* of the Window will shadow the Glass when the Sun is high in Summer, suppose within about 10. or 11. Inches of the Cieling, at least of that Cieling which belongs to the Window it self, then from that Point draw by the helps aforesaid, a *Meridian* upon a plane horizontally placed against the determined point in the Window, and to that *Meridian* finish an *Horizontal-Dial*, but instead of a Style to rise above the Plane, let it fall as much under the Plane, *viz.* according to the Elevation of the Pole, and in the Plane of the *Meridian*: then by the help of a Thred find where that Style would cut the floor, or any other place, if it was produced; and drive a Nail into it, with a Thred long enough to be extended to any part of the Cieling.

Fasten also another long Thred to the Center of the

Hori-

Horizontal-Dial, and desire one of your Friends to extend it horizontally, as the Plane will direct, and exactly over every Hour-Line in order, whilst you in the mean time extend the Thred which was fastned to the Nail in the Style, to the Cieling, but so as it may touch the other Horizontal Thred. Mark that Point in the Cieling which the extended Thred toucheth, and make more such Marks whereby to draw the Hour-line upon the Cieling, and do in like manner for the rest.

Lastly, Take all away, and place your Glass horizontally, and because your Glass hath a latitude, place it a little under the determined point, that the Center of the Glass may be just in the imaginary *Axis* which goes to the Nail, for wheresoever you place it, in that it will go true.

But because it may be troublesome to place an *Horizontal Dial* fast enough and exactly, and there is some hazard in finding exactly the point where the nail is to be driven, I will shew you another method which may be more easily practised.

First, Draw an *Horizontal-Dial* upon the back of some Table, or some Plaister-wall, or Floor.

Next, Draw a *Meridian* upon the Bay-board by a Thred or perpendicular black Line, as hath been said, passing through the point where you intend your *Reflecting-Glass* shall be, and by a Plumb-line translate it from the Bay-board to the Cieling.

Take the neareſt distance betwixt the Glass and the Cieling exactly.

With this distance come to your Dial on the Wall, and set one end of it on that part of the *Axis* where the other will just touch the *Meridian*. That point in the *Axis* may be called the Glass-point, from which erect

erect a perpendicular, and where it cuts the *Meridian* make a point, which will be the Æquinoctial point, from which also erect a perpendicular, which will be a *Tangent*; then at some distance on which side of the Æquinoctial point you find most convenient, erect another *Tangent*; these two *Tangents* will cut the Hour-lines in Points, which may be called the Hour-points.

Then take the Distance betwixt the Glass-point and the Æquinoctial point, and extend it from the Glass toward the *Meridian*, and where it toucheth, that is the Æquinoctial point upon the Cieling.

Lastly, Set off correspondent *Tangent*-lines upon the Cieling, and making like Hour-points, through those Points draw the Hour-lines, you need not blot out the Æquinoctial *Tangent*, it being pleasant to see how the Sun will go in that Line all day, when it is in the Æquinoctial. Besides the Æquinoctial point will tell you on that day whether your Glass lie horizontally, which is a hard matter by instruments to find: or upon any day you may calculate the Sun's *Meridian* Altitude, and see whether it falls just upon that Point in the *Meridian* at 12. a Clock.

This Dial is nothing but an *Horizontal* inverted, the Center whereof is in the Air without, except you make a *North-Dial* which is seldome done, and then it will be upon the Cieling, which you must find by its distance from the Æquinoctial point, and let that Center govern your *Tangents*. The ground of this Dial is, that the Angles of *Reflexion* are equal to the Angles of *Incidence*.

Sometimes instead of two *Tangents* you may use two Circles, especially when the Center of the Dial is upon the Cieling, or when your Glass is near the Window-Cieling, then the Æquinoctial-point will be

upon that Cieling, and you may project the Hour-lines upon the Chamber-Cieling, or the Walls, by one Thred extended over the Hour-line, and another Thred touching that, and extended from the *Æquinoctial*-point or any Point in the imaginary *Axis* to the Cieling or Wall.

You may draw the Lines with Charcoal, or red Oker, and rub them with your finger.

Let your Dial upon the Wall be drawn very true and fine, and remain to take Distances for uses at any other time.

I was once desired to consider how to make a Dial upon a Cylinder or Pillar of an House, which is easily done by a convenient Plane of Board or Past-board, cutting out (almost, or quite) much the greatest part of it, leaving but a Limb sufficient for strength, and some parts of the Hour-lines: if need be, over Past-board you may put fair paper, with water made of the Infusion (or boyling) of *Gumm-Arabick*, or *Gumm-Tragacanth*, or even tempered thin with *Wheat-flower*. Then fasten the Plane to the Cylinder, which it will touch in a perpendicular Line, and to what *Declination* you think most convenient, make a *Declining-Dial*, and fix the Style upon it, then cutting the aforesaid part quite off, by a Candle or your Eye see where the Style through every Hour directs upon the Cylinder, and set the *Axis* in that Point of the Cylinder, which it would enter, if it was produced. By the like means you may project as many Dials as you please, upon a great *Globe* or two Freestone *Hemispheres*, or upon a *Cone*, or what you please.

For an Horizontal Dial.

LET two Lines be drawn ſquare-wiſe; *viz. bd.* for the Hour of 12. and *bc.* for the Hour of 6. let the Style *b.i.* be drawn, ſo that the Angle *i.b.d.* may be equal to the Elevation of the *Pole*, *viz.* in this Example 52° 15′ take where you pleaſe any Point in the *Meridian-line*, ſuppoſe *d.* from which unto the Style let fall a perpendicular, *d.e.* let *d.f.* equal to *d.e.* be transferred to the *Meridian*, make a perpendicular to the *Meridian* in *d.* for a Line of *Contingence.*

From *f.* as a Center, deſcribe a Circle repreſenting the Æquinoctial at any conſiderable diſtance, (the bigger the better) and divide it into 24. parts for Hours, or 48. parts for Half-Hours. But it is enough for an *Horizontal-Dial*, if one *Quadrant* betwixt the Hours of 12. and 6. be divided into 6. parts or 12.

Make Points in the *Contingent*, where it ſhall be cut by a Ruler applyed to the Center and every Diviſion in the Æquinoctial.

Laſtly, Draw the Hour-lines from the Center *b.* and every Correſpondent-point in the *Contingent*, erecting the Style over the *Meridian* according to the Angle *i.b.d.*

There is alſo in the *Diagramm* a pricked *Quadrant*, from the Center *b.* in which the diſtance of the Hour-lines, from the *Meridian* are calculated for the Elevation of the *Pole* at *Cambridge*, 52° 17′ allowing to every Hour 15. Degrees; according to this Analogy.

Rad. 10.

Tang. 15. 9,428052.
Sin. 52° 17. 9,898201.

9,326253. *Tang.* 11° 58'

For 1. a Clock, and in like manner for the rest, as in the Figure.

At Stamford *the Pole is elevated* 52° 40'

The Horary Distances computed as directed, at the end of *Oughtr. Expl.* and in this Writing are

For an Horizontal.		
12	00	00
1	12	2
2	24	21
3	38	29
4	54	1
5	71	23
6	90	0

For a South-Dial.	
00	00
9	14
19	17
31	14
46	24
66	9
90	0

For a Vertical Declining Dial.

Suppose the Elevation of the Pole, 52° 25'.
The Declination towards the West, 41° 00.

FROM the Point of Intersection of two Lines drawn square-wise as before, *viz. b.* by the help of a Line of Chords, make an Angle equal to the Elevation of the *Æquator*, 37 35' *e.b.d.*

Make another *n.b.d.* equal to the Declination 41° draw *d.e.* perpendicular to the *Meridian*, from any Point taken at pleasure, suppose *d.* Make

Make *b.n.* equal to the Line *d e.* from *n.* let fall a perpendicular to the *Meridian n.m.* let this perpendicular *n.m.* be transferred, and ſet upon the former perpendicular, on the other ſide the *Meridian* equal to *d.p.*

Let the Subſtile be drawn through *b.* and *p.* unto which in the Point *p.* draw a perpendicular for the *Contingent*; let the Line *b.m.* be ſet upon the *Contingent* equal to *p.r.* then from the Center *b.* through *r.* draw the Style, whoſe altitude above the Subſtile ſhall be equal to the Angle *p.b.r.*

From *p.* to the Style let fall the perpendicular *p.s.* transfer this *p.s.* to the Subſtile equal to *p.o.* from the Center *o.* let the Æquinoctial Circle be deſcribed at any conſiderable diſtance, as before in the Horizontal, and divided into 24. or 48. parts, beginning the Diviſion in that part of the Circle, *W.* which is cut by the Ruler applyed to *o.* and *x.* which is the point of the Interſection of the *Contingent* and the *Meridian*, and note that the *Radius* will divide the Circle into ſix parts, which muſt be halved, *&c.*

Make points in the *Contingent*, where it is cut by a Ruler applyed to the Center *o.* and every diviſion.

Laſtly, From the Center of the Dial *b.* and every correſpondent Point in the *Contingent*, draw the Hour-lines.

You may alſo upon a Semicircle, as before, calculate this ſort of Dials, uſing the *Logarithms* by four Operations.

Operation 1.

As the Radius	10,000000.
to the Cotang. *Elev.* 37° 35.	9,886288.
So is the Sine of the Declin. 41°	9,816943.
to Tang. *Diſtance Subſt. from* Merid.	9,793231.

Opera.

Operation 2.

As Rad.	10, 00 00 00.
to Cosm. Decl. 49°	9,877780.
So Cosm. Elev. 37° 45′	9,785269.
to the Sine of the Style's Height above Subst.	9,663049--27° 25′.

Operation 3.

As Sin. Elev. 52. 25. Comp. Arith.	0,101019.
to Radius	10, 00 00 00.
So Tang. Declin.	9,939163.
to Tang. *Inclination of the* Merid. *of the Plane to* Merid. *of the Place.*	10,040182-47.39.

By the *Meridian* of the place, understand the Plane which passeth through the Style, the Line of the Hour of 12. and the *Zenith.*

By the *Meridian* of the Plane, understand the Circle which passeth through the Poles of the World, the Style and Substyle.

By the Inclination of these *Meridians* is understood an Angle at the Style, *viz.* at the Intersection of the two aforesaid Planes; which Angle is measured by an Arch of the *Æquator*, whose Plane cutteth them both at right Angles.

From this Angle so found by the 3ᵈ *Operat.* substract every 15 Degrees, till you come to *Addition.* Namely, from 47° 39′ take 15. rest 32° 39′ for the Angle at the Pole and first Hour, then say,

Operat.

Operat. 4.

As Rad.	10,00 00 00.
to Sine, Height of Style	9,663190.
So Tang. *of the Angle at the Pole comprehended between the Hour given, and the* Meridian *of the Plane,* 32° 39′	9,806693.
to Tang. *of Distance of the Hour-lines from the Substile.*	9,469883--16° 26′

And so in like manner for the rest of the Hours, but this is more for contemplation and exercise, and which you will seldom use in practice; the other being more ready, and grounded upon these Analogies.

The Table in *Oughtr. Expl. p.* 19. (when the Elevation of the Pole is 52° 25′, the Declination *Occid.* 41. 00.) filled up with the rest of the Distances from the Substile.

Height of the Style. 27° 25′.
Inclination of *Meridians*, 47° 39′.

Angles at the Pole.		Hours.	Distances.	
		12	26	47
32°	39′	1	16	26
17	39	2	8	20
2	39	3	1	13
12	21	4	5	45
27	21	5	13	23
42	21	6	22	46
57	21	7	35	42
72	21	8	55	21

FINIS.

AN Advertisement.

THE *Author finds so much Tin, especially in great Frames, to be somewhat inconvenient; for the outside of it by its brightness, makes the Frame too discernible to such as are without the House; and the inside will not easily take a black Colour; it being requisite that all the inside of the Frame should be blacked, to make the Spot to appear the brighter (and for the same it is best to set the Dial in the Window above the Level of the Eye) therefore the Author now fills up all the back-side with a thin Plate of Wood, leaving at the Bottom about half an Inch or less, to give light upon the Bottom-figures, and if need be, cuts little Slits at the Ends for the Figures at the End, pasting a little Paper on the Inside, so to let in nothing but necessary Light; then lastly, for the Top, he makes a Hole in the Plate of Wood, about an Inch and half long, and three quarters broad, and upon that nails a piece of Tin, or rather Copper-Plate.*